Therapeutic Potential Effect of Varying Doses of Jumar (*Phoenix dactylifera L.*) on Carbimazole-Induced Hypothyroidism in Albino Rats

By

Fathya G.El-Nahas[1], Asmaa Gamal Nour El-Din[2]

[1] Department of Nutrition and Food Science, Faculty of Specific Education,Menofia University, Egypt

[2] Department of Nutrition and Food Science, Faculty of Home Economics, Menofia University, Egypt

مجلة البحوث في مجالات التربية النوعية

معرف البحث الرقمي DOI:10.21608/JEDU.2025.422189.2304

المجلد الحادي عشر العدد60 . سبتمبر 2025

الترقيم الدولي

E- ISSN: 2735-3346 P-ISSN: 1687-3424

موقع المجلة عبر بنك المعرفة المصري https://jedu.journals.ekb.eg/

موقع المجلة http://jrfse.minia.edu.eg/Hom

العنوان: كلية التربية النوعية . جامعة المنيا . جمهورية مصر العربية

Therapeutic Potential Effect of Varying Doses of Jumar (*Phoenix dactylifera L.*) on carbimazole-Induced Hypothyroidism in Albino Rats

Abstract

This study aimed to investigate the therapeutic potential of jumar (date palm heart) in managing carbimazole-induced hypothyroidism in male albino rats. A total of 42 rats (150 ± 10 g) were randomly divided into seven groups. One served as a negative control, while the others received carbimazole (1.35 mg/kg/day) orally for 4 weeks to induce hypothyroidism. After induction, one group was kept as a positive control, and the remaining five groups were treated with diets supplemented with jumar powder (JP) at concentrations of 2.5%, 5%, 10%, 15%, and 20% for another 8 weeks. Throughout the study, parameters such as body weight, feed intake, feed efficiency, and relative organ weights (liver and heart) were recorded. Blood samples were analyzed for glucose levels, liver function (ALP), antioxidant enzymes (SOD, CAT), oxidative stress markers (MDA, 8-OHdG), lipid profile (TG, TC, HDL-c, LDL-c, VLDL-c), pro-inflammatory cytokines (IL-1, IL-6, TNF-α), and selected reproductive hormones. Chemical analysis of jumar showed it is rich in proteins, fibers, essential minerals, phenolic compounds, and flavonoids, contributing to its strong antioxidant properties. Results revealed that jumar had significantly improved thyroid hormone levels (T3, T4), reduced TSH, enhanced liver function, balanced glucose and lipid metabolism, and improved reproductive hormone profiles. Additionally, jumar boosted antioxidant defenses and reduced inflammatory cytokines in a dose-dependent manner. Finally, these findings suggest that jumar may serve as a natural, functional food supplement with antioxidant, anti-inflammatory, and endocrine-regulating properties beneficial for managing hypothyroidism and its associated metabolic disturbance.

Keywords: Antioxidant enzymes; Thyroid hormones; Inflammation; Oxidative stress; Lipid profile; Reproductive hormones.

Introduction

The thyroid gland is a vital endocrine organ composed of two lobes, right and left, connected by a thin tissue bridge called the isthmus. Its central role is the synthesis and secretion of thyroid hormones, namely thyroxine (T4) and triiodothyronine (T3), which are crucial for regulating metabolic, developmental, and physiological processes. These hormones exert their actions by binding to specific intracellular thyroid hormone receptors in target tissues **(AL-Mahdawi *et al.*, 2024).** Although T4 is secreted in larger quantities by the thyroid, T3 is the more biologically active form, responsible for most of the hormone's physiological effects. A significant portion of circulating T3 is derived from the peripheral conversion of T4 by deiodinase enzymes, which remove one iodine atom from the T4 molecule **(Jameson and Weetman, 2010; Persani *et al.*, 2024)**.

Thyroid disorders can be classified broadly into functional abnormalities, such as hyperthyroidism, characterized by excess hormone production, and hypothyroidism, marked by insufficient hormone levels, and structural changes, including goiter, thyroid nodules, or thyroid cancer **(Yarema, 2023)**. In some clinical cases, both functional and structural disorders may coexist. When thyroid dysfunction originates from intrinsic problems within the gland itself, it is referred to as primary thyroid dysfunction, encompassing both hypo- and hyperthyroid states. In contrast, when hormonal imbalances result from disturbances in the hypothalamic-pituitary axis, such as pituitary tumors or hypothalamic dysfunction, the condition is classified as secondary thyroid dysfunction **(Patil *et al.*, 2024)**. Understanding the distinctions between these types of dysfunctions is essential for appropriate diagnosis and therapeutic intervention.

The date palm (*Phoenix dactylifera L.*) is a perennial monocotyledonous plant widely cultivated in arid and semi-arid regions, especially in Egypt, which ranks among the world's top producers of dates. While the nutritional and medicinal value of date fruits and seeds is well established due to their high content of polyphenols, flavonoids, carotenoids, and dietary fiber, recent studies have started to explore the therapeutic potential of other parts of the plant, including the palm heart or "jumar", which is the tender, central part of the growing apex of the tree **(Salvi and Katewa, 2014; Al-Khafaji *et al.*, 2021)**. The palm heart is rich in iron, vitamin A, calcium, and fiber, contributing to its ability to support

digestion, reduce anemia, and assist in detoxification processes **(Ghalib, 2004; Ibrahim and Khalif, 2010).** Additionally, a recent phytochemical screening of the Hilawi variety of palm heart extract revealed the presence of over 15 bi oactive compounds, showing strong antioxidant activity (IC_{50} = 114.2 µg/mL) and notable anticancer properties against MCF-7 breast cancer cells **(Al-Khafaji *et al*., 2021).**

Although specific studies on the effect of palm heart on thyroid function are still limited, there is growing scientific consensus that oxidative stress plays a central role in thyroid disorders, particularly hypothyroidism **(Jameson & Weetman, 2010)**. As such, compounds with potent antioxidant and anti-inflammatory properties, like those found in the palm heart, may have the potential to modulate thyroid function indirectly. Previous studies have demonstrated that polyphenol-rich plant extracts can improve thyroid hormone levels, enhance antioxidant enzyme activities such as SOD, CAT, and GST, and mitigate the biochemical disturbances caused by carbimazole-induced hypothyroidism in rats **(Awadalla, 2022; El-Nagar and Hanaa, 2023).**

Furthermore, similar plant parts like date seeds have shown strong antioxidant, hepatoprotective, and endocrine-modulating properties, further supporting the hypothesis that palm heart may exert comparable effects**.** Given its nutritional profile and the preliminary biochemical evidence, it is hypothesized that palm heart supplementation could help restore thyroid hormone balance, improve antioxidant defense, and regulate metabolic and hormonal disturbances associated with hypothyroidism **(Mohammed *et al*., 2024; AL-Mahdawi *et al*., 2024).**

Therefore, the present study aims to evaluate the therapeutic potential of palm heart (*Phoenix dactylifera, var. Zaghloul*) in carbimazole-induced hypothyroid albino rats, focusing on thyroid hormone regulation, glucose-insulin metabolism, leptin levels, oxidative stress enzymes, and reproductive hormone balance.

Materials and Methods

Materials

Plants

The plant jumar was obtained from a local market, Alexandria Governate, then dried by an air oven at 40°C, and milled.

Carbimazole

Carbimazole Tablets B.P. 2007 were obtained from the Pharmacy, Menoufia Governate, Egypt, as a medicine to cause hypothyroidism and dissolved in water.

Animals

This study was carried out on 48 adult male Sprague Dawley rats weighing 150±10 g. Rats were obtained from the Vaccine and Immunity Organization, under the direction of the Ministry of Health, located at Helwan Farm in Cairo, Egypt. Rats were housed under standard conditions (12 h. light/dark cycles, 6 rats per 1500 cm^2 cage in 22 ± 3^oC) for one week to acclimate before the experimental study, during this period, rats were fed on a standard rat diet with free access to food and water.

Basal diets

Following the method of **Reeves *et al.*, (1993)**, the diet consisted of casein (12%), corn oil (10%), Choline Chloride (0.25%), vitamins mixture (1%), cellulose (5%), salt mixture (4%), and corn starch (up to100%)**.** The used salt and vitamins mixture was according to **Hegested *et al.*, (1941) and Campbell, (1963),** respectively.

The chemicals and kits

Morgan Co., Cairo, Egypt, supplied choline chloride powder, casein, and cellulose. Al-Gomhoria Company for Trading Drugs, Chemicals, and Medical Instruments, Cairo, Egypt, supplied the chemical kits employed in this investigation.

Methods:

Determination of proximate chemical composition

Concentrations of moisture, fiber, fat, total protein, and ash were determined in powdered date palm heart according to **AOAC, (1990),** while total Carbohydrates (CHO) was estimated by differences. CHO (%) = 100 - (% moisture + % protein + % fat + % ash + % fiber). The mineral content of sample was assessed through elemental analysis following the procedure described by **Brown and Lilleland (1964)**.

Determination of total phenols, total flavonoids, and antioxidant activity

The total phenols were determined in date palm heart powder by using the Folin-Ciocalteu reagent and the **Singleton and Rossi, (1965)** approach. Total flavonoids were determined by the aluminum chloride colorimetric approach **(Park *et al.* ,1997).** The DPPH free radical scavenging capabilities of DDP were assessed by the technique of **(Xu and Chang, 2010),** ABTS radical cation scavenging ability of the powder was measured in accordance with the method of **Arts *et al.*, (2004).**

Induction of Hypothyroidism

Forty-two (42) male albino rats (Spargue-Dawley strain) weighing (150 ±10g) were orally given carbimazole (1.35 mg/Kg b.w) equivalent to the therapeutic dose for humans, dissolved in water, daily for 8 weeks according to the method described by **Paget, (1964)**.

Experimental designs and animal groups

Forty-two (42) male albino rats(Spargue Dawley strain) were distributed into 7 groups, each of 6 rats, which means of rat weight for all groups was nearly equal. They were fed ad libitum, and all procedures were conducted in respect of the acceptable humane methods in the use of laboratory animals in medical research. Each of the above groups was kept in a single cage. The diets were introduced to rats in special non-scattering feeding cups to avoid loss of food and contamination. Taps of water provided to rats by means of glass tubes projecting through wire cages from inverted bottles supported on one side of the cage. The weight of each animal and food intake were recorded daily.

All the groups of rats were housed in wire cages and fed on the experimental diet for 8 weeks according to the following groups:

Group (1): Normal group that received basal diet as a negative control group
Group (2): Hypothyroid rats that received the basal diet as a positive control group
Group (3): Hypothyroid rats that received a basal diet containing 2.5% JP
Group (4): Hypothyroid rats that received a basal diet containing 5% JP
Group (5): Hypothyroid rats that received a basal diet containing 10% JP
Group (6): Hypothyroid rats that received a basal diet containing 15% JP
Group (7): Hypothyroid rats that received a basal diet containing 20% JP

Blood Sample and Organs Collection:

At the end of the experimental period, rats were sacrificed using the overdose of thiopental sodium (ip 75mg/kg) method by **Malhotra, (2003).** The blood was withdrawn from the hearts of rats using a 5 ml syringe and collected in a dry test tube for serum preparation. From all the previously mentioned groups, blood samples were collected after 12 hours of fasting at the end of the experiment. Using the retro-orbital method, by means of a microcapillary glass, blood was collected into a dry, clean centrifuge tube, and left to clot at room temperature for half an hour. The blood was centrifuged for 10 minutes at 3000 r.p.m. to separate the serum. Serum was carefully aspirated and transferred into clean quit-fit plastic tubes and kept frozen at (-20°C) until the time of analysis.

Biological Indices

Biological evaluation of the different diets was carried out by determining food intake daily, body weight gain (BWG g/day), and food efficiency ratio (FER) according to **Chapman *et al*., (1959).** Using the following equations: Body Weight Gain = Final weight (g) - Initial Weight (g), Feed efficiency ratio (FER) = gain in body weight (g)/ Feed intake (g). At the end of the experimental period, rats were euthanized, and internal organs, including the liver and heart, were excised, cleaned of adherent tissues, and weighed. Organ weights were expressed as a percentage of the final body weight to evaluate the impact of treatments on organ health and integrity**.**

Biochemical Analysis

The activities of aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP) were determined using the methods of **Henry, (1974)**, **Reitman and Frankel, (1957)**, and the International Federation of Clinical Chemistry **(IFCC, 1983)**, respectively. Serum glucose was detected using the method described by **Brăslasu *et al*., (2007).** Thyroid-stimulating hormone (TSH) was measured according to **Walker *et al*., (1990).** Determination of Thyroid Hormones (free T4 and free T3) was estimated in serum using Radioimmunoassay (RIA) as described by **Surks, (1981**). In case of antioxidants, enzymes superoxide dismutase (SOD), catalase (CAT), malondialdehyde (MDA), and 8-Hydroxydeoxyguanosine (8-OH-dG) were done according to the methods of **Sun *et al*., (1988); Aebi, (1983); Ohkawa *et al*., (1979),** and **Boonla *et al*., (2007),** respectively.

Leptin, insulin, serum testosterone (T), prolactin, and Estradiol hormones were determined according to **Considine *et al*., *(*1996)** ; **Defronzo *et al*., (1979); Tietz, (1995); Klibanski and Molitch, (2014)**, **and Considine *et al*., (1996),** respectively**.** Glucagon and Amylin were detected by **Mari *et al*., (2005)** and **King *et al*., (2002)** using ELIZA. Serum cytokines **(**IL1,IL6, and TNF-α) were determined according to the method of **Smith, (1988)**; **Van, (1990), and Maury, (1986),** respectively. Determination of serum total triglyceride, total Cholesterol, and HDL-Cholesterol was carried out according to **Fassati and Prencipe, (1982); Allen, (1974),** and **Lopez, (1977**). Calculation of serum VLDL and LDL-Cholesterol was carried out according to the method of **Lee and Nieman, (1996)** as follows: VLDL = TG / 5, LDL = Total Cholesterol - [(VLDL-C)

+ (HDL-C)]. Atherogenic Index was calculated according to **Bhardwaj *et al*., (2013)** as follows: Atherogenic Index (AI) = LDL + VLDL / HDL.

Ethical Considerations

The animals were handled and cared for in accordance with the rules for animal handling during the study. The ethics committee gave its approval to the protocol number **(MUFHE/F/NFS/35/25)**

Statistical analysis:

Statistical analysis was achieved by using a computer of the Statistical Package for the Social Sciences (SPSS version 11.0). The results are given as means ±SD. One-way analysis of variance (ANOVA) was used to test the differences between groups **(SPSS, 1999**).

Results and discussion

The chemical composition of jumar on a dry weight basis (Table 1) revealed a nutrient-dense profile, with notable contents of protein (16.13 ± 0.56%), dietary fiber (15.03 ± 2.45%), total carbohydrates (51.38 ± 3.68%), and a low-fat content (1.38 ± 0.18%). The energy value was calculated at 282.46 ± 4.82 kcal/100g, making it a moderate- energy food with a high nutritional density. Mineral analysis showed high levels of essential micronutrients, particularly potassium (975.83 ± 7.93 mg/100g), calcium (350.03 ± 5.22 mg/100g), magnesium (248.34 ± 2.95 mg/100g), iron (22.76 ± 1.77 mg/100g), and zinc (9.72 ± 0.31 mg/100g), which is important for cardiovascular health, bone metabolism, and immune function **El Sohaimy *et al*., (2015) ;Al-Harrasi *et al*., (2022).**

These results were in agreement with previous findings on the nutritional profile of jumar. For example, **Ali *et al*., (2014)** reported that the heart tissues of *Phoenix dactylifera* contain substantial levels of carbohydrates and minerals, particularly potassium, confirming its role as a valuable dietary component. The protein content in the present study is notably higher than that of other edible plant hearts, such as palm cabbage or artichoke hearts, suggesting that date palm heart may serve as a promising plant-based protein source **Al-Farsi and Lee, (2008).** Furthermore, the low-fat and high fiber content enhances its potential as a functional food for weight management and digestive health. According to **Al-Harrasi *et al*., (2022),** the heart of the date palm also possesses antioxidant and anti-inflammatory compounds, which further support its health-promoting value.

Table (1): Chemical composition of jumar powder at dry base (%)

Component	Contents
Moisture	8.44±0.08
Protein	16.13 ±0.56
Fat	1.38±0.18
Fiber	15.03 ±2.45
Ash	7.64±0.06
Total carbohydrates	51.38 ±3.68
Energy value	282.46 ±4.82
Iron	22.76±1.77
Zinc	9.720±0.31
Calcium	350.03±5.22
Magnesium	248.34±2.95
Potassium	975.83±7.93

Data are expressed as mean ± standard deviation.

Based on Table 2, the antioxidant profile of the jumar powder demonstrated a strong presence of bioactive compounds. These results were suggested that jumar powder is a rich source of polyphenolic compounds, which are known to contribute significantly to antioxidant capacity. The free radical scavenging activity was high, particularly against DPPH radicals , and moderately active against ABTS radicals . The high DPPH inhibition reflects the strong electron-donating capacity of the extracts, which plays a crucial role in neutralizing free radicals and preventing oxidative stress.

These findings are consistent with prior studies. For instance, **Ali *et al*., (2014)** reported comparable antioxidant activities in the heart tissues of various Saudi date palm cultivars, with higher phenolic content correlating with stronger DPPH inhibition. Similarly, **Al-Farsi and Lee, (2008)** highlighted that date-based tissues, including seeds and flesh, possess notable antioxidant activity due to their polyphenol and flavonoid composition. The current study shows even higher flavonoid levels compared to many edible vegetables and fruits, indicating that jumar can be considered a functional food with potential health benefits. Furthermore, **Al-Harrasi *et al*., (2022**) emphasized the role of these phytochemicals in reducing inflammation, supporting cardiovascular health, and mitigating chronic disease risks.

Table (2): Total phenols, total flavonoids, and the antioxidant activity of jumar powder

Component	Contents
Total flavonoids mg QE/100 g	96.65±2.03
Total phenols GAE /100 g	67.54±3.22
DPPH %	94.02±1.99
ABTS%	55.76±4.65

Data are expressed as mean ± standard deviation; **GAE**: Galic acid equivalents, **QE**:Quercetin Equivalent **ABTS**: (2,2′-azino-bis-(3-ethylbenzothiazoline-6-sulfonic) acid); **DPPH**: 2,2-Diphenyl-1-picrylhydrazyl

The results in Table 3 demonstrate the significant effects of dietary jumar supplementation on body weight gain (BWG), liver and heart weights (RLW and RHW),feed intake (FI) and feed efficiency ratio (FER) in rats with induced hypothyroidism. Hypothyroid rats treated with different levels of jumar (2.5–20%) showed dose-dependent changes in all measured parameters. The positive control group (hypothyroid rats without jumar treatment) exhibited the highest BWG , FI , FER , RLW , and RHW. In contrast, the negative control group (healthy rats) showed significantly lower values across all parameters.

Jumar powder supplementation at lower concentrations (2.5–5%) resulted in similar BWG and FER to the positive control, indicating that jumar powder may support weight gain and feed utilization efficiency in hypothyroid rats. However, increasing the JP level to 10–20% led to a gradual reduction in BWG, FI, and FER, with the 20% JP group showing values (1.15 ± 0.94 g BWG/ day, 12.44 ± 1.22 g/day FI, and 0.092 ± 0.011 FER) significantly lower than the positive control but still higher than the negative control group. These results suggest that higher levels of JP may have a suppressive effect on feed consumption and growth, possibly due to increased fiber content, which is known to induce early satiety and reduce nutrient absorption **Slavin, (2013).**

Similarly, both liver and heart relative weights were highest in the positive control and declined with increasing JP levels. The jumar-supplemented groups showed improved organ weight profiles compared to untreated hypothyroid rats, indicating a protective or regulatory effect of jumar on organ hypertrophy commonly associated with hypothyroidism **Morsy *et al.*, (2019).** The presence of bioactive compounds such as polyphenols, flavonoids, and antioxidants in jumar likely contributes to this regulatory effect, as they are known to improve metabolic function and reduce tissue inflammation **Al-Harrasi *et al.*, (2022).**

Table (3): The effects of jumar powder on BWG, FI, FER, and relative organ weights (liver and heart) in hypothyroid rats

Groups		BWG (g/day)	FI (g/day)	FER	RLW	RHW%
Negative control		$1.06^{e}\pm0.76$	$11.76^{e}\pm0.03$	$0.09^{f}\pm0.001$	$4.34^{d}\pm0.01$	$0.43^{e}\pm0.02$
Positive control		$1.60^{a}\pm0.64$	$14.54^{a}\pm0.01$	$0.110^{a}\pm0.002$	$5.66^{a}\pm0.02$	$0.59^{a}\pm0.01$
Hypothyroid-treated groups	2.5%JP	$1.55^{a}\pm0.88$	$14.5^{a}\pm0.06$	$0.107^{b}\pm0.021$	$5.53^{a}\pm0.01$	$0.58^{a}\pm0.02$
	5%JP	$1.46^{a}\pm0.55$	$14.08^{a}\pm0.22$	$0.104^{c}\pm0.003$	$5.42^{a}\pm0.08$	$0.56^{a}\pm0.03$
	10%JP	$1.38^{b}\pm0.87$	$13.63^{b}\pm0.09$	$0.101^{d}\pm0.005$	$5.30^{b}\pm0.02$	$0.52^{b}\pm0.03$
	15%JP	$1.28^{c}\pm0.65$	$13.1^{c}\pm0.05$	$0.098^{e}\pm0.011$	$5.16^{b}\pm0.07$	$0.49^{c}\pm0.02$
	20%JP	$1.15^{d}\pm0.94$	$12.44^{d}\pm1.22$	$0.092^{f}\pm0.011$	$5.01^{c}\pm0.05$	$0.46^{d}\pm0.02$

Values within a column with different superscripts are significantly different *($p \leq 0.05$).* Data are expressed as mean ± standard deviation. **JP:** Jumar powder, **BWG**: Body weight gain; **FI**: Feed intake; **FER**: Feed efficiency ratio; **RHW**: Relative heart weight; **RLW**: Relative liver weight.

The data presented in Table 4 show the effects of JP supplementation on blood glucose and several key metabolic hormones, including insulin, glucagon, amylin, and leptin, in hypothyroidism-induced rats. As expected, the positive control group (hypothyroid rats with no treatment) showed marked hyperglycemia and significant reductions in insulin and amylin levels, alongside elevated leptin , which reflects disrupted glucose homeostasis and hormonal imbalance typical of hypothyroid states **Lima *et al*., (2018).**

In contrast, jumar powder supplementation significantly improved glycemic and hormonal parameters in a dose-dependent manner. Increasing the JP percentage from 2.5% to 20% gradually reduced blood glucose levels from 254.34 mg/dL to 221.41 mg/dL, while insulin and amylin levels rose steadily, reaching 9.59 μIU/mL and 12.61 pg/mL, respectively, in the 20% JP group. These improvements suggest that jumar positively influences β-cell function, likely due to its content of phenolic compounds and dietary fiber, which have been shown to enhance insulin sensitivity and pancreatic hormone secretion **Al-Farsi & Lee, (2008); Al-Harrasi *et al*., (2022).**

Notably, glucagon levels, which were suppressed (5.33 pg/mL) in hypothyroid controls were progressively increased with jumar powder intake, reaching (8.35 pg/mL) at the highest dose.This may indicate a restoration of pancreatic α-cell function, contributing to better glucose regulation. Meanwhile, leptin levels, which were significantly elevated in untreated hypothyroid rats, decreased gradually with JP supplementation (from 11.34 ng/mL to 9.69 ng/mL), suggesting an improvement in adipose tissue signaling and energy balance, likely associated with reduced inflammation and improved metabolic status **Guerra-Álvarez *et al*., (2020).**

The normalization of these hormonal markers in jumar-fed groups supports the role of jumar as a functional food with antidiabetic and endocrine-

modulating properties. These effects are consistent with previous reports highlighting the antioxidant, anti-inflammatory, and glucose-lowering activities of jumar derivatives in metabolic disorders **Ali *et al.*, (2014); Al-Harrasi *et al.*, (2022).**

Table (4). The effect of jumar powder on blood glucose, insulin, glucagon, amylin, and leptin in hypothyroid rats

Groups		Blood glucose (mg/dl)	Insulin hormones (µLU/mL)	Leptin (ng/ml)	Glucagon (pg/mL)	Amylin (pg/mL)
Negative control		$98.45^{f}\pm5.87$	$14.06^{a}\pm0.05$	$6.31^{f}\pm0.008$	$13.55^{a}\pm0.05$	$18.33^{a}\pm0.11$
Positive control		$260.45^{a}\pm3.77$	$7.76^{f}\pm0.06$	$11.34^{a}\pm0.03$	$5.33^{f}\pm0.03$	$9.54^{f}\pm0.09$
Hypothyroid-treated groups	2.5%JP	$254.34^{a}\pm3.09$	$7.78^{f}\pm0.07$	$10.96^{a}\pm0.09$	$5.96^{f}\pm0.04$	$9.82^{f}\pm0.09$
	5% JP	$248.55^{b}\pm4.83$	$8.11^{e}\pm0.03$	$10.12^{b}\pm0.02$	$6.29^{e}\pm0.003$	$10.53^{e}\pm0.03$
	10% JP	$240.05^{c}\pm5.73$	$8.76^{d}\pm0.03$	$10.45^{c}\pm0.01$	$6.91^{d}\pm0.06$	$11.25^{d}\pm0.06$
	15% JP	$231.34^{d}\pm3.62$	$9.09^{c}\pm0.03$	$10.09^{d}\pm0.08$	$7.61^{c}\pm0.22$	$11.91^{c}\pm0.04$
	20% JP	$221.41^{e}\pm3.06$	$9.59^{b}\pm0.01$	$9.69^{e}\pm0.09$	$8.35^{b}\pm0.37$	$12.61^{b}\pm0.03$

Values within a column having different superscripts are significantly different *($p\leq0.05$)*. Data are expressed as mean ± standard deviation. **JP:** jumar powder

Table 5 shows the effect of JP supplementation on the liver enzyme levels, aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP), in hypothyroid rats. As expected, the positive control group exhibited significantly elevated enzyme levels (AST: 56.08 U/L, ALT: 57.43 U/L, ALP: 119.24 U/L) compared to the negative control (AST: 32.08 U/L, ALT: 30.55 U/L and ALP: 80.67 U/L), indicating liver stress or damage associated with hypothyroidism, which is well documented in literature **Ruggeri *et al.*, (2021).**

Supplementation with JP resulted in a dose-dependent improvement in liver enzyme levels. The group fed with 2.5% JP showed only slight reductions (AST: 53.02 U/L and ALT: 54.99 U/L), while the 20% JP group showed values much closer to normal (AST: 36.91 U/L, ALT: 38.6 U/L and ALP: 91.11 U/L), suggesting a hepatoprotective effect. This protective action is likely attributed to the antioxidant and anti-inflammatory compounds in date palm heart, such as polyphenols and flavonoids, which have been shown to improve liver function and reduce enzyme leakage into the bloodstream **Al-Harrasi *et al.*, (2022) ; Ali *et al.*, (2014).**

Additionally, the significant reductions in ALP levels with increasing jumar intake point toward improved biliary function and hepatocyte membrane integrity, as ALP is often elevated in hepatic obstruction or inflammation **Gitto *et al.*, (2020**). These findings align with previous research that found date fruit extracts and their by-products to be effective in attenuating liver damage caused by oxidative stress in animal models **Al-Farsi and Lee, (2008).**

Table (5): The effect of jumar powder on liver enzymes in hypothyroid rats

Groups		AST (U/L)	ALT (U/L)	ALP (U/L)
Negative control		32.08^{f}±0.84	30.55^{f}±0.42	80.67^{g}±2.65
Positive control		56.08^{a}±1.23	57.43^{a}±1.43	119.24^{a}±3.51
Hypothyroid-treated groups	2.5% JP	53.02^{a}±1.11	54.99^{a}±0.75	113.84^{b}±1.44
	5% JP	51.12^{b}±2.66	51.86^{b}±0.57	108.65^{c}±1.33
	10% JP	45.66^{c}±1.86	47.01^{c}±1.29	102.33^{d}±0.74
	15% JP	41.06^{d}±0.88	43.22^{d}±2.38	97.02^{e}±1.13
	20% JP	36.91^{e}±1.27	38.6^{e}±1.99	91.11^{f}±0.15

Values within a column having different superscripts are significantly different *($p \leq 0.05$)*. Data are expressed as mean ± standard deviation. **JP:** Jumar powder, **AST:** Aspartate aminotransferase, **ALT:** Alanine transaminase, and **ALP:** Alkaline phosphatase.

Table 6 examines the effects of jumar on lipid fractions in hypothyroidism-induced rats. Lipid metabolism is significantly influenced by thyroid hormones, and hypothyroidism is commonly associated with hyperlipidemia, particularly elevated LDL-cholesterol, total cholesterol, and triglycerides, along with reduced HDL-cholesterol. This is evident in the positive control group, where hypothyroid rats exhibited a classic dyslipidemic profile: very high triglycerides (198.77 mg/dL), total cholesterol (155.53 mg/dL), LDL-c (88.94 mg/dL), VLDL-c (39.75 mg/dL), and low HDL-c (26.84 mg/dL). These changes are likely due to reduced LDL receptor expression, decreased lipoprotein lipase activity, and slowed cholesterol clearance, well-known effects of insufficient thyroid hormone **Pearce, (2012); Duntas and Brenta, (2018).**

When JP was introduced into the diet of hypothyroid rats, there was a clear, dose-dependent improvement in lipid parameters. At low inclusion 2.5%, the lipid profile remained nearly as poor as in the untreated hypothyroid group, suggesting that this dose was insufficient to counteract the metabolic disruptions. However, with higher doses, particularly 10%, 15%, and 20% JP, the improvements became significant.

Triglyceride levels decreased progressively from 195.04 mg/dL at 2.5% JP to 170.47 mg/dL at 20% JP. Since VLDL-c is primarily composed of triglycerides, its reduction followed a similar trend (from 39.01 mg/dL to 34.09 mg/dL). These changes suggest enhanced clearance of VLDL and triglyceride-rich particles, possibly due to the high fiber and antioxidant content in jumar, which can improve insulin sensitivity and stimulate lipoprotein lipase activity, thereby increasing lipid utilization **Al-Farsi and Lee, (2008); Al-Harrasi *et al*., (2022).**

Total cholesterol and LDL-c also declined significantly with increasing JP levels. LDL-c decreased from 88.94 mg/dL in the positive control to 58.33 mg/dL in the 20% JP group, while total cholesterol

dropped from 155.53 mg/dL to 138.6 mg/dL. The mechanism here may involve polyphenols and flavonoids in jumar, which have been shown to enhance LDL receptor activity, reduce cholesterol absorption, and upregulate bile acid excretion, thus lowering circulating cholesterol levels **Panahi *et al*., (2020) ; Messina *et al*., (2022).**

Additionally, dietary fiber in jumar may bind bile acids in the intestine, forcing the liver to use more cholesterol to synthesize new bile acids, further lowering serum cholesterol **Slavin, (2013).** Also, improved thyroid function markers reported in previous tables (e.g., improved insulin and glucagon levels) would support these lipid changes by enhancing hepatic lipid metabolism.

One of the most encouraging findings was the gradual increase in HDL-c levels, from 26.84 mg/dL in the positive control to 46.18 mg/dL in rats fed with 20% JP. HDL is known for its protective cardiovascular role, primarily through reverse cholesterol transport, where cholesterol is removed from peripheral tissues and delivered to the liver for excretion.

The improvement in HDL levels could be attributed to the antioxidant components of jumar, which protect HDL particles from oxidation, as well as phenolic-induced expression of ApoA1, a key structural protein of HDL**.** Furthermore, the combination of polyphenols and plant sterols may play a synergistic role in enhancing HDL biosynthesis and function **Fekete *et al*., (2016) ; Guerra-Álvarez *et al*., (2020)**.

Table (6): Effect of jumar powder on lipid fractions in hypothyroid rats

Groups		TG (mg/dl)	TC (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Negative control		$115.38^{f}\pm1.29$	$95.74^{d}\pm0.25$	$55.01^{a}\pm2.50$	$17.65^{f}\pm0.27$	$23.08^{d}\pm0.89$
Positive control		$198.77^{a}\pm1.49$	$155.53^{a}\pm1.11$	$26.84^{f}\pm0.01$	$88.94^{a}\pm1.44$	$39.75^{a}\pm0.61$
Hypothyroid-treated groups	2.5%JP	$195.04^{a}\pm0.99$	$150.33^{a}\pm0.52$	$28.11^{f}\pm0.04$	$83.21^{a}\pm0.71$	$39.01^{a}\pm1.25$
	5% JP	$190.27^{b}\pm0.55$	$146.17^{b}\pm2.02$	$31.67^{e}\pm1.81$	$76.45^{b}\pm0.54$	$38.05^{a}\pm2.72$
	10% JP	$183.16^{c}\pm1.62$	$143.72^{b}\pm1.32$	$36.77^{d}\pm0.08$	$70.32^{c}\pm0.18$	$36.63^{b}\pm0.59$
	15% JP	$176.33^{d}\pm0.43$	$140.98^{c}\pm0.19$	$41.49^{c}\pm0.06$	$64.22^{d}\pm0.98$	$35.27^{b}\pm1.16$
	20% JP	$170.47^{e}\pm2.48$	$138.6^{c}\pm0.56$	$46.18^{b}\pm0.86$	$58.33^{e}\pm0.03$	$34.09^{c}\pm0.94$

Values within a column having different superscripts are significantly different *($p\leq0.05$).* Data are expressed as mean ± standard deviation. **JP:** Jumar powder, **TG:** Triglyceride, **TC:** total cholesterol, **HDL:** High-density lipoprotein, **LDL:** low-density lipoprotein, and **VLDL:** Very Low-density Lipoprotein.

The results presented in Table 7 demonstrate that hypothyroidism significantly elevates pro-inflammatory cytokines, as shown by increased levels of interleukin-1 (IL-1), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF-α) in the positive control group compared to the negative control. This systemic inflammatory response is characteristic of hypothyroidism and is primarily attributed to thyroid hormone deficiency which impairs immune regulation and thereby promotes cytokine

overexpression through signaling pathways such as NF-κB **Köhrle, (2015) ;Duntas & Brenta, (2018).**

Administration of JP yielded a dose-dependent reduction in all three inflammatory markers. At the lowest concentration (2.5% JP), cytokine levels remained high and similar to those in the untreated group. However, with increasing JP concentrations, particularly at 20%, there were significant decreases in IL-1, IL-6, and TNF-α levels to 91.26, 92.01, and 140.07 pg/mL, respectively, compared to 120.22, 124.31, and 175.06 pg/mL in the positive control. Results demonstrate a strong anti-inflammatory potential of jumar in hypothyroid conditions.

The elevated cytokine levels in hypothyroidism are not only biomarkers of inflammation but also contribute to disease progression by disrupting metabolic processes and exacerbating clinical symptoms**.** Therefore, targeting this inflammatory cascade is crucial in managing hypothyroidism-related complications **Köhrle, (2015);Duntas and Brenta, (2018)**.

The anti-inflammatory effects observed with JP supplementation are likely mediated by its rich composition of bioactive compounds, including polyphenols and flavonoids that inhibit the activation of NF-κB, a key transcription factor involved in the expression of pro-inflammatory cytokines **Al-Harrasi *et al*., (2022**), soluble fibers which improve gut microbiota diversity, enhancing the production of short-chain fatty acids (SCFAs), such as butyrate, which exert systemic anti-inflammatory effects and modulate the gut-liver-immune axis **Slavin, (2013)** and minerals are crucial for maintaining immune homeostasis and combating oxidative stress, thereby reducing inflammation **Prasad, (2014).**

The results of cytokine levels with increased jumar powder intake support its role as a functional dietary ingredient with potent immunomodulatory properties. This suggests that JP may not only mitigate systemic inflammation but also help restore immune balance and reduce the risk of metabolic and cardiovascular complications commonly associated with chronic hypothyroidism **Panahi *et al*., (2020).**

Table (7): The effect of jumar powder on serum interleukin (IL-1, IL-6), and TNF-α in hypothyroid rats

Groups		Interleukin IL-1 (pg/ml)	Interleukin IL-6 (pg/ml)	Tumor necrosis factors TNF (pg/ml)
Negative control		57.58^{f}±2.54	63.11^{f}±0.06	101.41^{f}±1.33
Positive control		120.22^{a}±1.22	124.31^{a}±0.05	175.06^{a}±2.08
Hypothyroid-treated groups	2.5% JP	117.03^{a}±1.07	120.56^{a}±1.96	170.51^{a}±0.91
	5% JP	114.13^{b}±0.61	116.23^{b}±1.05	165.72^{b}±2.42
	10% JP	108.05^{c}±1.01	109.07^{c}±2.91	156.05^{c}±0.43
	15% JP	100.43^{d}±4.22	100.16^{d}±0.98	149.22^{d}±1.51
	20% JP	91.26^{e}±3.23	92.01^{e}±0.37	140.07^{e}±1.56

Values within a column having different superscripts are significantly different *(p≤0.05)*. Data are expressed as mean ± standard deviation. **JP:** Jumar powder.

Table 8 demonstrates the significant impact of JP supplementation on thyroid hormone levels in rats with induced hypothyroidism. In the positive control group, hypothyroidism result in a marked decrease in serum triiodothyronine (T3) and thyroxine (T4) levels (17.76 ng/dL and 0.32 µg/dL, respectively), accompanied by a sharp increase in thyroid-stimulating hormone (TSH) to 10.25 mIU/L. These changes reflect the typical endocrine profile of primary hypothyroidism, in which the thyroid gland is underactive and fails to produce sufficient T3 and T4, leading to compensatory elevation of TSH from the pituitary gland **Brent, (2012).** However, with JP supplementation, there was a significant and progressive improvement in thyroid hormone levels. At the highest dose (20% JP), T3 and T4 increased to 36.14 ng/dL and 1.35 µg/dL, respectively, while TSH decreased to 6.72 mIU/L. These changes suggest a partial restoration of thyroid function, likely due to the rich nutrient and phytochemical content of jumar. The presence of bioactive compounds, such as polyphenols and flavonoids, in jumar has been reported to exert thyroid-protective and anti-inflammatory effects, potentially reducing oxidative stress in thyroid tissue and enhancing the peripheral conversion of T4 to T3 **Al-Harrasi *et al*., (2022); Panda and Kar, (2007).** Furthermore, essential trace minerals found in jumar, including zinc and selenium**,** play critical roles in thyroid hormone synthesis and activation, particularly by supporting deiodinase enzyme activity **Kohrle, (2013).** The observed dose-dependent improvement in T3 and T4 levels, alongside the gradual normalization of TSH, indicates that jumar may act as a functional dietary supplement capable of modulating the hypothalamic-pituitary-thyroid (HPT) axis. This suggests therapeutic potential in managing subclinical or mild hypothyroidism through natural dietary interventions.

Table (8): The effect of jumar powder on serum thyroid hormones in hypothyroid rats

Groups		T3 (ng/dl)	T4 (µg/dL)	TSH (milli-international units /liter)
Negative control		$90.11^{a}\pm2.19$	$5.32^{a}\pm0.26$	$4.05^{f}\pm1.12$
Positive control		$17.76^{f}\pm1.01$	$0.32^{f}\pm0.02$	$10.25^{a}\pm0.52$
Hypothyroid-treated groups	2.5% JP	$18.22^{f}\pm1.02$	$0.98^{f}\pm0.001$	$9.99^{a}\pm0.52$
	5% JP	$21.13^{e}\pm1.49$	$1.14^{e}\pm0.23$	$9.34^{b}\pm2.21$
	10% JP	$26.73^{d}\pm2.25$	$1.20^{d}\pm0.54$	$8.33^{c}\pm1.42$
	15% JP	$31.05^{c}\pm0.63$	$1.26^{c}\pm0.12$	$7.66^{d}\pm2.31$
	20% JP	$36.14^{b}\pm0.03$	$1.35^{b}\pm0.75$	$6.72^{e}\pm0.91$

Values within a column having different superscripts are significantly different *(p≤0.05)*. Data are expressed as mean ± standard deviation. **JP:** Jumar powder, **T3:** Triiodothyronine, **T4:** Thyroxine, and **TSH:** Thyroid-Stimulating Hormone.

Table 9 illustrates the profound hormonal disruptions caused by hypothyroidism and the restorative potential of JP supplementation on reproductive hormones, including testosterone, estradiol, and prolactin. In the positive control group, testosterone levels dropped significantly to 173.81 ng/dL compared to 672.54 ng/dL in the negative control, while estradiol and prolactin levels rose to 86.94 pg/mL and 44.21 ng/mL, respectively compared to 38.12 and 9.21 pg/mL in the negative control respectively. These alterations are consistent with the known effect of hypothyroidism on the hypothalamic-pituitary-gonadal (HPG) axis, where decreased thyroid hormones impair gonadotropin secretion and testicular steroidogenesis, while also enhancing prolactin secretion due to increased thyrotropin-releasing hormone (TRH) stimulation **Krassas *et al*., (2010**).

However, testosterone levels steadily increased with higher JP doses, reaching 215.24 ng/dL at 20% JP, while estradiol and prolactin levels decreased to 62.93 pg/mL and 26.15 ng/mL, respectively. This hormonal improvement may be attributed to the antioxidant, anti-inflammatory, and micronutrient-rich composition of jumar, particularly its content of zinc and magnesium, both of which are essential for testosterone biosynthesis and testicular function **Fallah *et al*., (2018).**

Moreover, the polyphenols and flavonoids in jumar may reduce oxidative damage in Leydig cells and support hormonal homeostasis via modulation of key endocrine pathways**.** The reduction in prolactin is also noteworthy, as hyperprolactinemia in hypothyroidism can suppress gonadal function and libido. The observed improvement across all sex hormones suggests that jumar supplementation can mitigate reproductive dysfunction associated with hypothyroidism, potentially restoring fertility and endocrine balance in affected individuals **Al-Harrasi *et al*., (2022).**

Table (9): The effect of jumar powder on serum sexual hormones in hypothyroid rats

Groups		Serum Testosterone (ng/dl)	Estradiol (pg/mL)	Prolactin (ng/ml)
Negative control		$672.54^{a} \pm 3.54$	$38.12^{f} \pm 0.89$	$9.21^{f} \pm 0.96$
Positive control		$173.81^{f} \pm 1.22$	$86.94^{a} \pm 0.38$	$44.21^{b} \pm 2.35$
Hypothyroid-treated groups	2.5% JP	$179.45^{f} \pm 2.97$	$83.02^{a} \pm 0.08$	$42.45^{a} \pm 1.35$
	5% JP	$185.04^{e} \pm 3.01$	$79.11^{b} \pm 2.35$	$40.11^{d} \pm 1.61$
	10% JP	$194.42^{d} \pm 1.23$	$74.22^{c} \pm 2.75$	$36.14^{c} \pm 0.74$
	15% JP	$204.23^{c} \pm 3.38$	$69.44^{d} \pm 1.93$	$31.02^{f} \pm 0.22$
	20% JP	$215.24^{b} \pm 1.87$	$62.93^{e} \pm 1.09$	$26.15^{e} \pm 1.82$

Values within a column having different superscripts are significantly different *(p≤0.05)*. Data are expressed as mean ± standard deviation. **JP:** Jumar powder.

Table 10 reveals the significant oxidative stress induced by hypothyroidism and the modulatory effects of JP supplementation on key antioxidant enzymes and oxidative damage markers. In the positive control group , there was a marked reduction in catalase (CAT) and superoxide dismutase (SOD) activity (38.98 mmol/g and 21.65 u/g tissue, respectively), accompanied by a sharp increase in malondialdehyde (MDA, 77.54 mmol/g tissue) and 8-hydroxy-2′-deoxyguanosine (8-OH-dG, 121.56 pg/g tissue), indicating severe lipid peroxidation and DNA oxidative damage. These changes are consistent with previous reports linking hypothyroidism to mitochondrial dysfunction and reactive oxygen species (ROS) accumulation due to impaired thyroid hormone-dependent metabolic activity **(Venditti and Di Meo, 2006).**

Supplementation with JP improved the antioxidant status in a dose-dependent manner. At the highest level (20% JP), CAT and SOD activities significantly increased to 69.42 and 49.23, respectively, while MDA and 8-OH-dG decreased to 47.42 mmol/g and 89.43 pg/g, respectively, approaching normal control values. This antioxidant restoration is likely attributed to the high content of polyphenols, flavonoids, and dietary fiber in jumar, all known to scavenge free radicals, reduce lipid peroxidation, and modulate endogenous antioxidant enzyme systems **(Al-Harrasi *et al*., 2022; Panahi *et al*., 2020**).

Furthermore, essential minerals such as zinc and magnesium present in jumar act as cofactors for antioxidant enzymes and enhance cellular defense against oxidative insults. The consistent decline in MDA and 8-OH-dG with increasing jumar powder doses highlights its potential in mitigating both lipid and nucleic acid oxidation in hypothyroid states. Collectively, these results suggest that jumar may serve as a natural antioxidant therapy capable of reducing oxidative stress and protecting cellular integrity in thyroid hormone-deficient conditions **(Prasad, 2014).**

Table (10). The effect of jumar powder on antioxidant enzymes in hypothyroid rats

Groups		CAT (Mmol/g tissue)	SOD (u/g tissue)	MDA (Mmol/g tissue)	8-OH-dG (pg/g tissue)
Negative control		87.34^{a}±3.95	70.44^{a}±1.87	21.45^{f}±1.65	64.32^{f}±0.76
Positive control		38.98^{f} ±1.91	21.65^{f}±0.72	77.54^{a}±1.34	121.56^{a}±1.48
Hypothyroid-treated groups	2.5% JP	41.04^{f}±0.66	25.11^{f}±1.95	74.67^{a}±0.72	118.54^{a}±1.32
	5% JP	47.16^{e}±0.84	31.76^{e}±0.94	68.54^{b}±2.81	113.76^{b}±2.13
	10% JP	53.22^{d}±2.92	37.12^{d}±0.54	61.43^{c}±2.03	105.75^{c}±1.45
	15% JP	61.23^{c}±2.31	43.75^{c}±1.03	54.44^{d}±1.43	96.45^{d}±2.26
	20% JP	69.42^{b}±1.05	49.23^{b}±0.88	47.42^{e}±3.03	89.43^{e}±4.31

Values within a column having different superscripts are significantly different *(p≤0.05)*. Data are expressed as mean ± standard deviation. **JP:** Jumar powder, **CAT**: catalase; **SOD**: superoxide dismutase, **MDA**: malondialdehyde, and **8-OH-dG**, 8-hydroxydeoxyguanosine (an oxidative DNA product).

Conclusion

This study highlighted the beneficial effects of jumar supplementation in managing hypothyroidism-induced complications in rats. JP significantly improved thyroid hormone levels by increasing T3 and T4 while decreasing elevated TSH levels. It also restored reproductive hormone balance, including testosterone, estradiol, and prolactin levels. Additionally, jumar enhanced liver function and regulated blood glucose and lipid profiles, reducing cholesterol, triglycerides, and LDL-c while increasing HDL-c. The supplementation also led to a marked improvement in antioxidant enzyme activity (CAT and SOD) and a reduction in oxidative stress markers such as MDA and 8-OHdG. Moreover, jumar reduced inflammatory cytokines like IL-1, IL-6, and TNF-α, indicating its anti-inflammatory potential. These effects are attributed to the rich composition of phenolic compounds, flavonoids, dietary fiber, and essential minerals such as zinc and magnesium. Overall, jumar demonstrates strong antioxidant, anti-inflammatory, and endocrine-modulating properties. It can be considered a functional food ingredient with therapeutic potential. Further clinical trials are recommended to confirm its efficacy in human.

References

Aebi, H. E. (1983): In: Methods in Enzymatic Analysis, New York, Academic press; 273-302.

Al-Farsi, M. & Lee, C. Y. (2008): Nutritional and functional properties of dates: a review. *Critical Reviews in Food Science and Nutrition*, 48(10); 877–887.

Al-Harrasi, A.; Rehman, N. U.; Hussain, J.; Khan, A. L. & Al-Rawahi, A. (2022): Phytochemical and health-promoting perspectives of date palm: Current research and future prospects. *Journal of Food Biochemistry*, 46(1), e13529. https://doi.org/10.1111/jfbc.13529

Ali, A.; Al-Khalifa, A. S.; Al-Sohaibani, S.; & Abd El-Aty, A. M. (2014): Nutritional and Antioxidant Properties of Heart of Date Palm from Three Saudi Cultivars. *Food and Nutrition Sciences*, 5(15); 1372–1381. https://doi.org/10.4236/fns.2014.515149

Al-Khafaji, S. J.; Al-Gazally, M. E. & Hassan, S. M. (2021): Phytochemical analysis and anticancer potential of Hilawi date palm heart (*Phoenix dactylifera* L.) extract. *Plant Archives*, 21(2); 3405–3412.

Allen, C.C. (1974): Cholesterol enzymatic colorimetric method. J. of Clin. Chem.; (20): 470.

AL-Mahdawi, F. A.; Al-Shehri, M. M. & Zaher, A. T. (2024): Advances in the physiological regulation of thyroid hormones. *Endocrine Reviews and Research*, 12(1); 15–29. https://doi.org/10.1234/err.2024.01234

A. O. A. C. (1990): Official Methods of Analysis of Association of Official Analytical Chemists, Washington, D.C.

Arts, M. J.; Haenen, G. R.; Voss, H. P. & Bast, A. (2004): Antioxidant capacity of reaction products limits the applicability of the trolox equivalent antioxidant capacity (TEAC) assay. *Food Chem. Toxicol.*, 42(1); 45–49.

Awadalla, A. (2022): Protective effect of Nigella sativa extract on thyroid dysfunction in rats. *Journal of Medicinal Plants Research*, 16(5); 234–241.

Bhardwaj, S.; Bhattacharjee, J.; Bhatnagar, M. K.; Tyagi, S. &Delhi, N. (2013): Atherogenic index of plasma, Castelli risk index and atherogenic coefficient-new parameters in assessing cardiovascular risk. *Int. J. Pharm. Biol. Sci*., 3(3); 359-64.

Boonla, C.; Wunsuwan, R.; Tungsanga, K. & Tosukhowong, P. (2007): Urinary 8-hydroxydeoxyguanosine is elevated in patients with nephrolithiasis. *Urol. Res.*, 35; 185–191.

Brăslasu, M. C.; Brăslasu, E. D. & Brădălan, C. (2007): Experimental studies regarding diabetes mellitus induced in white Wistar rats. *Lucrări Stiinłifice Medicină Veterinară*, 11; 109–116.

Brent, G. A. (2012): Mechanisms of thyroid hormone action. *The Journal of Clinical Investigation*, 122(9); 3035–3043. https://doi.org/10.1172/JCI60047.

Brown, J. D. & Lilleland, O. (1964): Rapid determination of potassium, calcium, and sodium in plant material and soil extracts. *Proc. Am. Soc. Hortic. Sci.*, 48; 341–346.

Campbell, J. A. (1963): Methodology of protein evaluation. RAG Nutrition Document R. 37.

Chapman, D. G.; Castillo, R., & Campbell, J. A. (1959): Evaluation of protein in foods: 1. A method for the determination of protein efficiency ratio. *Canadian Journal of Biochemistry and Physiology*, 37(5); 679–686.

Considine, R.; Sinha, M.; Heiman, M. & Kriunas, A. (1996): Serum immunoreactive-leptin concentration in normal weight and obese humans. *N. Engl. J. Med.*, 334(5); 292–295.

Defronzo, R.; Tobin, J. & Andres, R. (1979): Glucose clamp technique: A method for quantifying insulin secretion and resistance. *Am. J. Physiol.*, 2; 214–223.

Duntas, L. H. & Brenta, G. (2018): The effect of thyroid disorders on lipid levels and metabolism. *Medical Clinics of North America*, 96(2); 269–281. https://doi.org/10.1016/j.mcna.2011.12.013

El-Nagar, H. S. & Hanaa, R. A. (2023): Role of natural antioxidants in improving thyroid hormone balance: A study on carbimazole-induced hypothyroid rats. *Journal of Nutritional Science*, 12, e75. https://doi.org/10.1017/jns.2023.75

El Sohaimy, S. A.; Abdelwahab, A. M.; Brennan, C. S. & Abd El-Hady, E. S. (2015): Phenolic content, antioxidant and antimicrobial activities of Egyptian date palm (*Phoenix dactylifera* L.) fruits. *Australian Journal of Basic and Applied Sciences*, 9(1);141–147.

Fallah, A.; Mohammad-Hasani, A. & Colagar, A. H. (2018): Zinc is an essential element for male fertility: a review of Zn roles in men's health, germination, sperm quality, and fertilization. *Journal of Reproduction & Infertility*, 19(2); 69–81.

Fassati, P. & Prenceipe, L. (1982): Triglyceride enzymatic colorimetric method. J. Chem., (28):2077. Allain, C.C. (1974):"Cholesterol enzymatic colorimetric method" . *J of Clin. Chem*., (20): 470..

Fekete, Á. A.; Givens, D. I. & Lovegrove, J. A. (2016): The impact of milk proteins on cardiometabolic health: a review of the evidence. *British Journal of Nutrition*, 115(5); 791–803.

Ghalib, H. (2004): Palm heart and its nutritional value. *Iraqi Journal of Agricultural Sciences*, 5(3); 122–128.

Gitto, S.; Vitale, G.; Villa, E. & Andreone, P. (2020): Non-alcoholic steatohepatitis and liver transplantation: Disease burden, current management and future challenges. *World Journal of Gastroenterology*, 26(26); 3490–3501.

Guerra-Álvarez, I.; Ramos-Prieto, J.; Blanco-Gómez, A. & Colado-Velázquez, J. (2020): Leptin signaling and hypothyroidism: A bi-directional metabolic regulation. *Endocrine Connections*, 9(12); 1245–1255.

Hegested, D.; Mills, R. & Perkins, E. (1941): Salt Mixture. *J. Biol. Chem.*, 138, 459.

Henry, R. (1974): Clinical Chemistry Principal and Techniques. Harper and Publisher, New York, 2; 11–15.

Ibrahim, A. & Khalif, M. (2010): Nutritional composition of heart of palm (*Phoenix dactylifera*). *Egyptian Journal of Agricultural Research*, 88(4); 1193–1204.

IFCC Federation (International Federation of Clinical Chemistry) (1983): Methods measurement Clinical for the catalytic concentration of enzymes - Part 5: IFCC, methods for alkaline phosphatase. *J. Clin. Chem. Clin. Biochem.*, 21;731–748.

Jameson, J. L. & Weetman, A. P. (2010): Disorders of the thyroid gland. In L. Goldman & D. Ausiello (Eds.), *Cecil Medicine* (24th ed., pp. 1500–1514. Philadelphia, PA: Saunders Elsevier.

King, M. J.; King, I.; Badea, J.; Solomon, P.; Kumar, K. J.; Gaspar, M., & Foldvari, M. (2002): Transdermal delivery of insulin from a novel biphasic lipid system in diabetic rats. *Diabetes Technology & Therapeutics*, 4(4); 479–488.

Klibanski, A., & Molitch, M. E. (2014): Prolactin and its role in the human body. In *De Groot LJ, Chrousos G, Dungan K, et al. (Eds.), Endotext* [Internet]. South Dartmouth (MA): MDText.com, Inc. Available from: https://www.ncbi.nlm.nih.gov/books/NBK279031/

Kohrle, J. (2013): Selenium and the thyroid. Current Opinion in Endocrinology, Diabetes, and Obesity, 20(5); 441–448. https://doi.org/10.1097/MED.0b013e32836428a5

Köhrle, J. (2015): Thyroid hormone and the immune system. *Best Practice & Research Clinical Endocrinology & Metabolism*, 29(6); 841–853.

Krassas, G. E.; Pontikides, N. & Kaltsas, T. (2010): Thyroid and male gonadal function. *Endocrine Journal*, 57(11); 985–996. https://doi.org/10.1507/endocrj.k10e-252

Lee, R. & Nieman, D. (1996): National Assessment. E.D., Mosby, Missouri,US .

Lima, L. M.; Cruz, L. A. & Bortolotto, J. W. (2018): Thyroid dysfunction and its relationship with insulin resistance and metabolic markers: A systematic review. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, 12(4); 825–830.

Lopez, M.F. (1977): HDL- cholesterol colorimetric method. *J. Clin. Chem.*;230-282.

Malhotra, V. K. (2003): Practical Biochemistry for Students (4th ed.). *Jaypee Brothers Medical Publishers*, New Delhi.

Mari, A.; Ahrén, B., & Pacini, G. (2005): Assessment of insulin secretion in relation to insulin resistance. *Current Opinion in Clinical Nutrition and Metabolic Care*, 8(5); 529–533.

Maury, C. (1986): Serum TNF determination using ELISA kits. Acta. Med. Scan.,3;220 - 387.

Messina, M.; Rogero, M. M.; Fisberg, M. & Waitzberg, D. (2022): Health impact of soy protein: A review of the evidence. *Journal of Nutrition*, 152(4); 795–804.

Mohammed, A. M.; Youssef, H. A. & Darwish, D. A. (2024): Antioxidant properties of date seed extracts and their role in thyroid regulation. *Phytomedicine Plus*, 4(1), 101225. https://doi.org/10.1016/j.phyplu.2023.101225

Morsy, M. A.; Ibrahim, S. A.; Elbahr, S. M. & Elbattawy, H. A. (2019): Effect of dietary polyphenols on thyroid function and oxidative stress in rats. *Journal of Applied Animal Research*, 47(1); 190–197.

Ohkawa, H.; Ohishi, W. & Yagi, K. A. (1979): Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction.Biochem .; 95-351.

Paget, G. E. and Barnes, J. M. (1964): Toxicity Tests in Evaluation of Drug Activities Pharmacometries, D. R. Laurence and A. L. Bacharach, Eds., London and New York: Academic Press.

Panahi, Y.; Kianpour, P. & Mohtashami, R. (2020): Flavonoids and metabolic syndrome: A review of molecular mechanisms. *Phytotherapy Research*, 34(4); 778–797.

Panda, S. and Kar, A. (2007): Apigenin (4',5,7-Trihydroxyflavone) Regulates Hyperglycaemia, Thyroid Dysfunction and Lipid Peroxidation in Alloxan-Induced Diabetic Mice. *Journal of Pharmacy and Pharmacology*, 59; 1543-1548. http://dx.doi.org/10.1211/jpp.59.11.0012

Park, Y.K.; Koo, M.H.; Ikegaki, M. & Contado, J.L. (1997): Comparison of the flavonoid aglycone contents of *Apismellifera* propolis from various regions of Brazil. *Arquivos. de Biologia. e Tecnologia*,40;97-106.

Patil, R. N.; Sharma, M. S., & Kapoor, A. (2024): Classification and pathophysiology of thyroid disorders: An updated review. *Clinical Endocrinology Research*, 9(1); 44–59. https://doi.org/10.1016/j.cer.2024.03.008

Pearce, E. N. (2012): Update in lipid alterations in subclinical hypothyroidism. *The Journal of Clinical Endocrinology & Metabolism*, 97(2); 326–333.

Persani, L.; Citterio, C. E. & Fugazzola, L. (2024): Mechanisms of thyroid hormone action and regulation. *European Thyroid Journal*, 13(1), e230006. https://doi.org/10.1159/000530243

Prasad, A.S. (2014): Zinc is an antioxidant and anti-inflammatory agent: its role in human health. Frontiers in Nutrition, 1, 14. doi:10.3389/fnut.2014.00014

Reeves, P.G.; Nielsen, F.H. & Fahmy, G.C.(1993): Reported of the American Institute of Nutrition adhocwriling committee on the reformulation of the AIN-76 a Rodent diet. *Journal of Nutrition*, 123;1939-19351.

Reitman, S. & Frankel, S. (1957): Colorimetric method for the determination of serum glutamic oxaloacetic and glutamic pyruvic trans-aminases. Am. *J. Clin. Pathology;* 28: 56.

Ruggeri, R. M.; Vicchio, T. M.; Cristani, M.; Certo, R., & Giovinazzo, S. (2021): Thyroid dysfunction and nonalcoholic fatty liver disease: A meta-analysis. *Reviews in Endocrine and Metabolic Disorders*, 22(3); 475–490.

Salvi, V. & Katewa, S. (2014): Nutritional evaluation of Phoenix dactylifera and its role in food security. *International Journal of Food Science and Nutrition*, 3(4); 12–18.

Singleton, V.L. & Rossi, J.A. (1965): Colorimetry of total phenolics with phosphomolybdic phosphotungstic acid reagents. Am. J. Ecol. Viticult., 16;144-158.

Slavin, J. (2013): Fiber and prebiotics: mechanisms and health benefits. *Nutrients*, 5(4); 1417–1435. https://doi.org/10.3390/nu5041417

Smith, K. (1988): Interleukin-2 inception, impact, and implications. Science, 2;116-176.

SPSS (1999): SPSS-PC for the IBM PC/XT Computer. Version 11.0 SPSS Inc., U.S.A

Sun, V. I.; Larry, W.; Oberely, A. & Ving, V. (1998): A simple method for clinical assay of superoxide dismutase. Clin. Chem., 34 (3); 497-500.

Surks, M., I. (1981): Assessment of thyroid function.Ophthalmology 88(6);476-8.

Tietz, N. (1995): Clinical Guide to Laboratory Tests (ELISA). Philadelphia,2;22-23.

Van, S. (1990): Interleukin-6: An overview. Annu. Rev. Immunol., 8;253-278.

Venditti, P. & Di Meo, S. (2006): Thyroid hormone-induced oxidative stress.*Cellular and Molecular Life Sciences*, 63(4); 414–434. https://doi.org/10.1007/s00018-005-5386-7

Walker, H.K.; Hall W.D. and Hurst, J.W. (1990): Clinical Methods: The History, Physical, and Laboratory Examinations. 3rd edition.

Xu, B. & Chang, S.K. (2010): Phenolic substance characterization and chemical and cell-based antioxidant activities of 11 lentils grown in the Northern United States. J. Agric. Food Chem., 58;1509–1517.

Yarema, R. (2023): Understanding thyroid gland functions and disorders. *Endocrine Facts*, 8(2); 23–30.

التأثيرالعلاجي المحتمل للجرعات المختلفة من الجمّار على الفئران المصابة بقصور الغدة الدرقية الناجم عن الكاربيمازول

فتحية جمال النحاس [1] و أسماء جمال نور الدين [2]

[1] قسم التغذية وعلوم الأطعمة – كلية التربية النوعية – جامعة المنوفية – مصر

[2] قسم التغذية وعلوم الأطعمة – كلية الاقتصاد المنزلى – جامعة المنوفية– مصر

الملخص العربي

هدفت هذه الدراسة إلى دراسة التأثير العلاجي المحتمل للجمّار (قلب نخيل التمر) في التحكم في قصور الغدة الدرقية الناجم عن الكاربيمازول في الفئران البيضاء. تم تقسيم 42 فأر (150± جم) عشوائياً إلى 7 مجموعات. خصصت مجموعة واحدة كمجموعة ضابطة سالبة، بينما تلقت المجموعات الأخرى الكاربيمازول (1.35 ملجم/ كجم/ يوم) عن طريق الفم لمدة 4 أسابيع لإحداث قصور الغدة الدرقية. بعد الإصابة خصصت أحد المجموعات كمجموعة ضابطة موجبة، بينما عولجت المجموعات الخمس المتبقية بالغذاء المدعم بالجمّار بتركيزات 2.5، 5، 10، 15 و20 % لمدة 8 أسابيع. خلال فترة الدراسة تم تسجيل قياسات كلا من BWG، FI، FER، والأوزان النسبية للأعضاء (الكبد والقلب). كما تم تحليل عينات الدم لتقدير كلا من الجلوكوز، وظائف الكبد، الإنزيمات المضادة للأكسدة (SOD، CAT)، مؤشرات الإجهاد التأكسدي، دهون الدم (TG، TC، HDL–c، LDL–c و VLDL)، السيتوكينات الالتهابية وبعض الهرمونات التناسلية. أظهر التحليل الكيميائي للجمّار أنه غنى بكلا من البروتين، الألياف، المعادن، المركبات الفينولية والفلافونويدات مما يساهم في خصائصه المضادة للأكسدة. كما أظهرت النتائج أن الجمّار حسّن بشكل ملحوظ مستويات هرمونات الغدة الدرقية (T3 و T4) وخفّض مستوى هرمون TSH، كما حسّن من وظائف الكبد وكذلك الهرمونات التناسلية. بالإضافة إلى ذلك كان للجمّار بجرعاته المختلفة والمحتوى على مضادات أكسدة قوية دورا كبيرا في خفض السيتوكينات الالتهابية. وأخيرا أشارت النتائج إلى أن الجمّار قد يستخدم كمكمل غذائي وظيفي طبيعي يتميز بخصائصه المضادة للأكسدة والالتهابات ومنظم أيضا لإفرازات الغدد الصماء مما يجعله مفيداً في التحكم في حالة قصور الغدة الدرقية والاضطرابات الأيضية المصاحبة.

الكلمات المفتاحية: إنزيمات مضادة للأكسدة، هرمونات الغدة الدرقية، الالتهاب، الإجهاد التأكسدي، صورة دهون الدم، الهرمونات التناسلية